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**DESIGN AND SIMULATION OF EVA TOOLS
AND ROBOT END EFFECTORS FOR
SERVICING MISSIONS OF THE HST**

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ABSTRACT

The Hubble Space Telescope (HST) was launched into near-earth orbit by the Space Shuttle Discovery on April 24, 1990. The payload of two cameras, two spectrographs, and a high-speed photometer is supplemented by three fine-guidance sensors that can be used for astronomy as well as for star tracking. A widely reported spherical aberration in the primary mirror causes HST to produce images of much lower quality than intended. A Space Shuttle repair mission in January 1994 installed small corrective mirrors that restored the full intended optical capability of the HST.

A Second Servicing Mission (SM2) scheduled in 1997 will involve considerable Extra Vehicular Activity (EVA). To reduce EVA time, the addition of robotic capability in the remaining servicing missions has been proposed. Toward that end, two concept designs for a general purpose end effector for robots are presented in this report.

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Design and Simulation of EVA Tools and Robot End Effectors for Servicing Missions of the HST

1. Background:

The Hubble Space Telescope (HST) was launched into near-earth orbit by the Space Shuttle Discovery on April 24, 1990. The HST's components and science instruments are modular to facilitate in-orbit servicing during its expected 15 year operational time span. A widely reported spherical aberration in the primary mirror caused HST to produce images of much lower quality than intended. A Space Shuttle repair mission in January 1994 installed small corrective mirrors that restored the full intended optical capability of the HST. Four additional servicing missions are planned in the future. The Second Servicing Mission (SM2) is expected to take place in February 1997 and the remaining missions in 1999, 2001, and 2005.

The First Servicing Mission (FSM) involved five days of Extra Vehicular Activity (EVA). On the basis of the experience gained during the FSM, the addition of robotic capability on the remaining service missions has been proposed. The primary purpose of the robotic systems would be to relieve the astronauts of some of the laborious and repetitive tasks of the earlier mission.

Tasks that could be done robotically to assist the astronauts are presented in Reference 1. A general purpose end effector (GPEE) will be required for the servicing missions and for space station applications. Such devices will have advantages where tasks are repetitive, time consuming, and laborious. A concept design for a GPEE is presented in this report.

2. Requirements:

The requirements for a GPEE are derived from the end effector requirements for the Servicing Aid Tool (SAT) and are listed as follows:

1. The ability to grasp a payload interface plate (Fig. 1) and Micro interface (Fig 2).
2. The ability to grasp a ORU handrail.
3. Built-in 7/16" socket drive tool.
4. Mechanically robust to react to 110% of SAT maximum forces and moments in the power-off mode.
5. Integral vision and lighting capability.
6. Capable of EVA override in case of failure.

3. General Purpose End Effector:

The outline of the concept designs of the proposed general purpose end effector is shown in Figs. 3 and 4. The design is based on an acme screw drive which is inherently non backdrivable when in the power-off mode. Each jaw is independently driven by a separate drive composed of a DC brushless motor and an epicenter gear train. The option of separate drives for each jaw is attractive since it allows for independent control of each finger. This arrangement simplifies motion control of each finger in difficult-to-reach workspace environments. In addition, it facilitates emergency decoupling of the payload with a single jaw. Each drive shaft has been provided with a 3/8-inch socket for EVA override in case of failure. The gripper jaws have been designed to grasp the standard H-plate (payload interface plate) and ORU handrails. A gripper with jaws designed for the micro interface and H-plate interface is shown in Fig. 3 while a second concept with rollers included to reduce friction while gripping the H-plate is shown in Fig. 4. Detailed calculations were made to size acme screws, select various transmission components, and select the brushless motors. Since the design is still in the concept stage, these calculations have not been included.

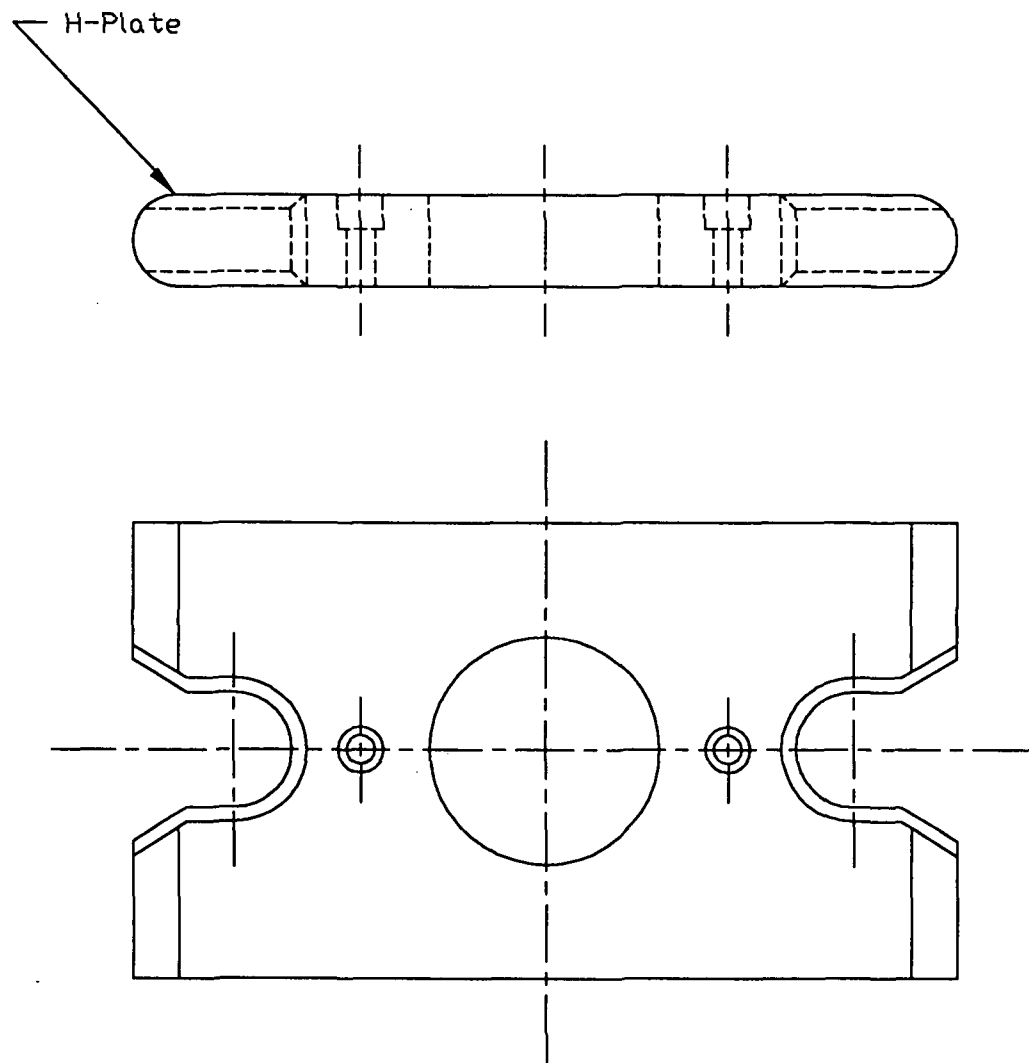
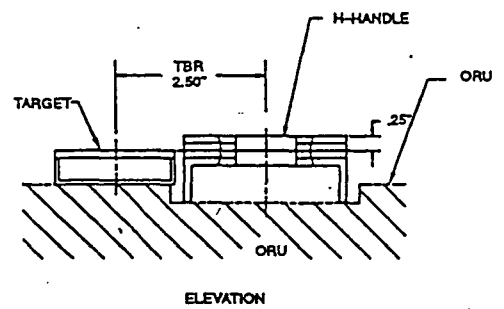
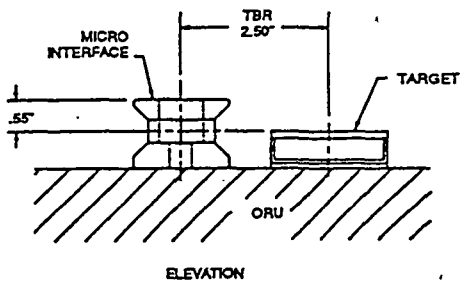
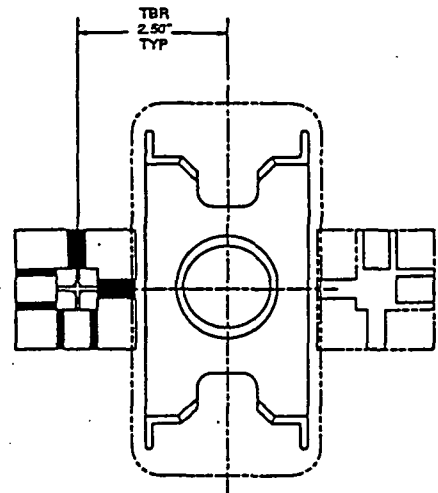
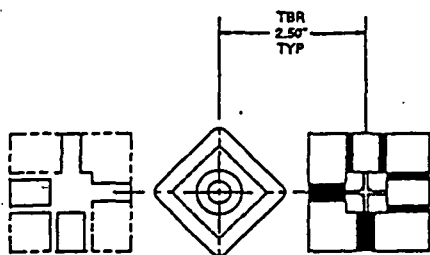


Fig. 1 H-Plate Interface



INTEGRATING THE DEXTEROUS HANDLING TARGET WITH A
MICRO INTERFACE

INTEGRATING THE DEXTEROUS HANDLING TARGET WITH
AN H-HANDLE

Fig. 2 Alpha Interface Attachment

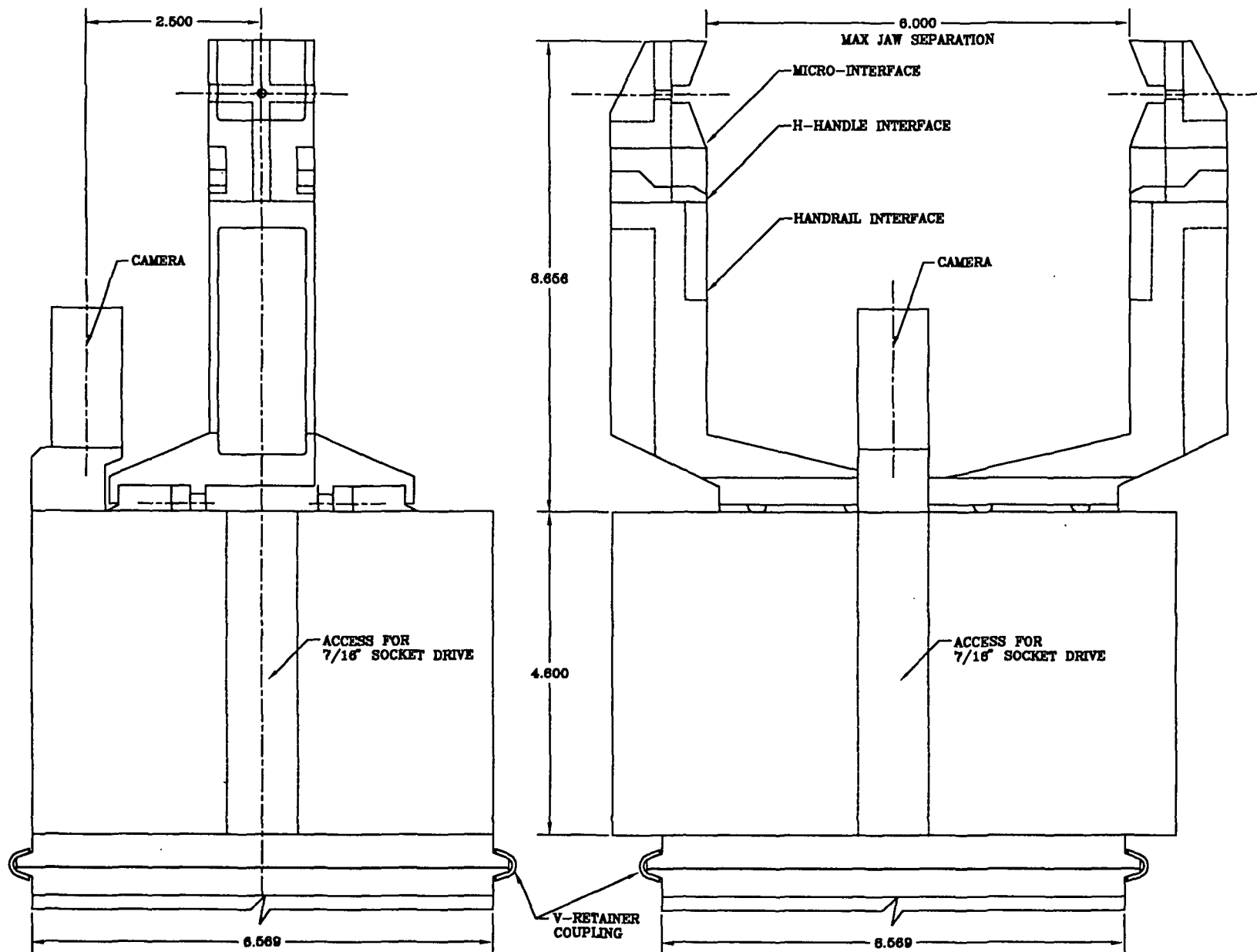


Fig. 3 General Purpose End Effector (Concept - 1)

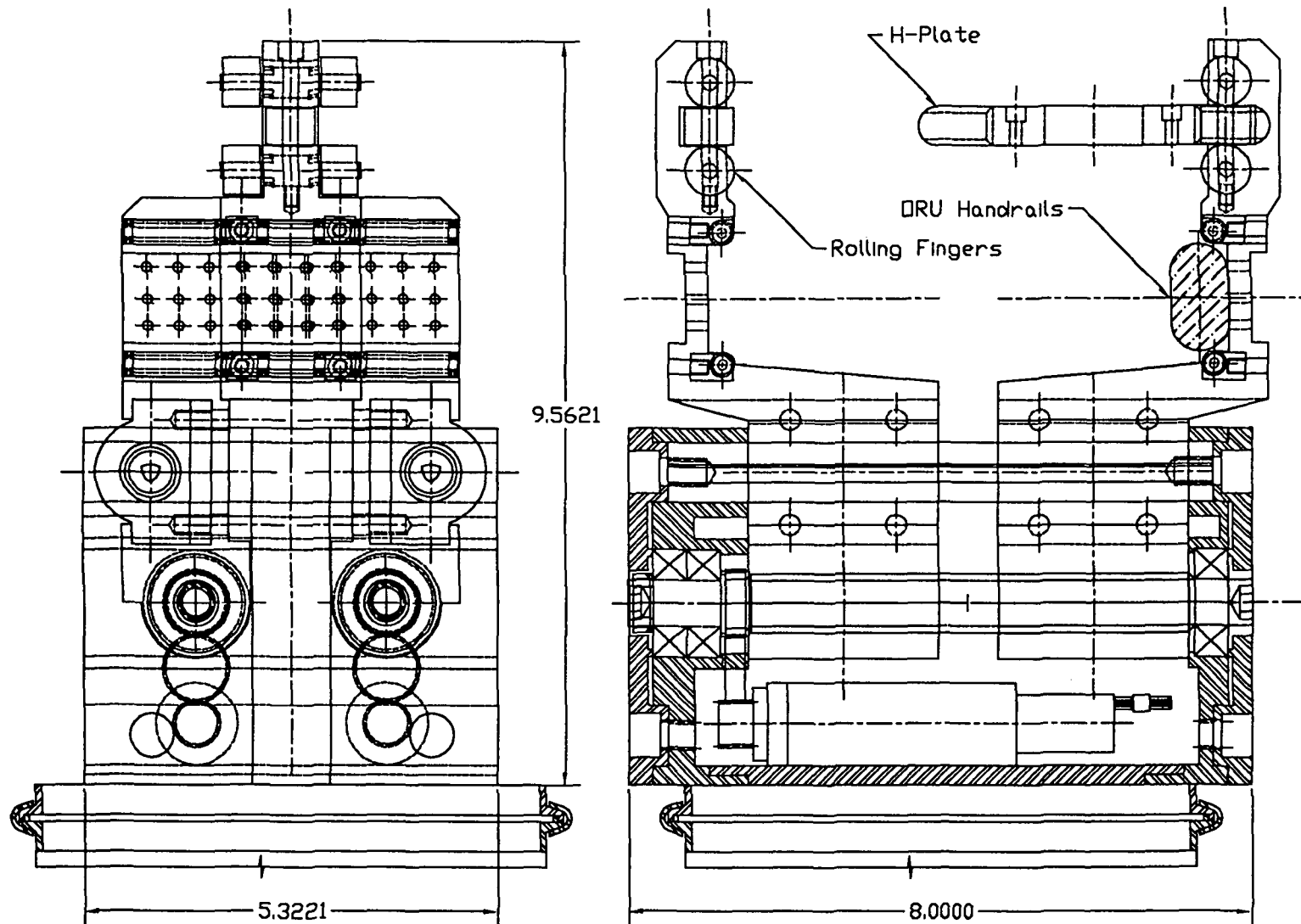


Fig. 4 General Purpose End Effector (Concept - 2)

REFERENCES:

1. " Applications of a Robotic Servicing Tool to the HST Second Servicing Mission: An Internal Study of Benefits and Constraints", March 1994.